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(54) **IMPROVEMENTS IN SECURITY DEVICES**

VERBESSERTE SICHERHEITSVORRICHTUNGEN

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Description

[0001] The present invention relates to improvements in security devices that can be used in varying shapes and sizes for various authenticating or security applications, and in particular to an optically variable security device utilising liquid crystal materials.

[0002] The increasing popularity of colour photocopiers and other imaging systems and the improving technical quality of colour photocopies has led to an increase in the counterfeiting of banknotes, passports and identification cards and the like. There is, therefore, a need to add additional authenticating or security features to existing security features. Steps have already been taken to introduce optically variable features into substrates used in such documentation that cannot be reproduced by a photocopier. There is also a demand to introduce features which are discernible by the naked eye but which are "invisible" to, or viewed differently, by a photocopier. Since a photocopying process typically involves scattering high-energy light off an original document containing the image to be copied, one solution would be to incorporate one or more features into the document which have a different perception in reflected and transmitted light, an example being watermarks and enhancements thereof.

[0003] It is known that certain liquid crystal materials exhibit a difference in colour when viewed in transmission and reflection, as well as an angularly dependent coloured reflection. Liquid crystal materials have been incorporated into security documents, identification cards and security elements with a view to creating distinctive optical characteristics. EP-A-0435029 is concerned with a data carrier, such as an identification card, which comprises a liquid crystal polymer layer or film in the data carrier. The liquid crystal polymer is solid at room temperature and is typically held within a laminate structure. The intention is that the liquid crystal layer, which is applied to a black background, will demonstrate a high degree of colour purity in the reflected spectrum for all viewing angles. Automatic testing for verification of authenticity is described using the wavelength and polarization properties of the reflected light in a single combined measurement. This has the disadvantage of being optically complex using a single absolute reflective measurement requiring a uniform liquid crystal area on a black background.

[0004] AU-A-488,652 is also concerned with preventing counterfeit copies by introducing a distinctive optically-variable feature into a transparent window security element. This document discloses the use of a liquid crystal "ink" laminated between two layers of plastic sheet. The liquid crystal is coated on a black background so that only the reflected wavelengths of light are seen as a colour. The security feature is primarily provided by thermochromic liquid crystal materials, which have the characteristic of changing colour with variation in temperature.

[0005] Cholesteric liquid crystals have certain unique

properties in the chiral nematic phase. It is the chiral nematic phase which produces an angularly dependent coloured reflection and a difference in colour when viewed in either transmission or reflection. Cholesteric liquid crystals form a helical structure which reflects circularly polarised light over a narrow band of wavelengths. The wavelength is a function of the pitch of the helical structure which is formed by alignment within the liquid crystal material. An example of such a structure is depicted in Figure 1 with the cholesteric helical axis in the direction of the arrow X. The reflection wavelength can be tuned by appropriate choice of chemical composition of the liquid crystal. The materials can be chosen to be temperature sensitive or insensitive. Both handednesses of circularly polarised light can be reflected by choice of the correct materials and thus high reflectivities at specific wavelengths can be achieved with double layers of liquid crystals. The wavelength of reflected light is also dependent on the angle of incidence, which results in a colour change perceived by the viewer as the device is tilted (see Figure 2).

[0006] On a dark background, only the reflective effect is observed, since little light is being transmitted from behind. When the dark background is removed or is otherwise not present and the device is viewed in transmission, the intensity of the transmitted colour saturates the reflective colour. Of the light which is not reflected, a small proportion is absorbed and the remainder is transmitted through the liquid crystal material. When correctly configured there is a dramatic change between the transmitted colour in the direction of arrow Y and reflected colour in the direction of arrow Z (see Figure 3). The region on either side of the liquid crystal layer in Figure 3 is a transparent polymer or glass. To achieve this effect, the area of the substrate which is occupied by the liquid crystal must be transparent or translucent. The transmitted and reflected colours are complementary, for example, a green reflected colour produces a magenta transmitted colour.

[0007] Liquid crystal materials can be incorporated into security devices either as a film, as for example in WO-A-03061980, or in the form of an ink as a liquid crystal pigment in an organic binder, as for example in EP-A-1156934. The advantage of a liquid crystal ink is that it can be applied using conventional printing processes and therefore it is relatively straightforward to apply the liquid crystal material in the form of a design. However the colour purity, brightness and sharpness of the observed colour and colour-shift are significantly degraded for a pigmented liquid crystal ink compared to a liquid crystal film. This degradation is due to the variability in alignment of the cholesteric helical axis between the individual liquid crystal pigments compared to the uniform alignment of the liquid crystal film.

[0008] A disadvantage with the use of liquid crystal films in the security devices described in the prior art is that the production route requires several steps, such as preparing the liquid crystal polymer film on a carrier sub-

strate, and then transferring the liquid crystal polymer film from the carrier substrate to the substrate of the security device. It is neither straightforward nor cost-effective to customise the base liquid crystal film for each security application.

[0009] In the prior art the visual appearance of multi-layer security devices utilising liquid crystal films have been customised by the incorporation of additional layers prior to the device being applied to the substrate. For example, in EP-A-0435029 a security device is customised by applying a black printed image under the liquid crystal layer. In WO-A-03061980 a liquid crystal security thread is customised by the introduction of demetallised characters using a dark resist. WO-A-03061980 discloses a method of manufacturing a security substrate, which combines the use of demetallised indicia with the colour-shift effect of liquid crystal materials.

[0010] The afore-mentioned prior art documents describe security devices comprising single layer liquid crystal films. The fact that the reflected light from a liquid crystal film is over a narrow band of wavelengths, which is a function of the pitch of its helical structure, limits the range of colours available for the security devices of the prior art cited above to substantially pure spectral colours. In addition the colourshift exhibited by a liquid crystal film is always from a colour with a long wavelength to a colour with a shorter wavelength, for example red to green, as the an angle of incidence is increased away from normal incidence.

[0011] A method of increasing the range of available colours in liquid crystal films is described in US4,893,906, in which two or more liquid crystal coatings are overlaid to obtain new colours as a result of the colour additive properties of the liquid crystal coatings which do not absorb light. WO-A-2005105474 describes a security device comprising two superimposed cholesteric liquid crystal layers in which the additive mixing of the colours permits a wider range of colourshift effects. In some of the embodiments in WO200510546 regions exhibiting different colourshifting effects are created by a partial application of one of the liquid crystal layers in localised areas. A partial application of a liquid crystal film is not straightforward and increases significantly the complexity of the production process compared to simply applying one uniform film over a second uniform film.

[0012] The object of the present invention is to provide a security device comprising two or more layers of liquid crystal materials which overcomes the problems of the prior art.

[0013] The present invention provides a security device comprising a first layer of an optically variable liquid crystal material which reflects light of a wavelength depending on the angle of incidence, a second layer of an optically variable liquid crystal material which reflects light at a different wavelength dependent on the angle of incidence to the first layer, and a partial first layer of a light-absorbing material between the first and second liquid crystal layers.

[0014] A preferred embodiment of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:-

5 Figure 1 depicts chiral nematic alignment of a cholesteric liquid crystal material;

10 Figure 2 shows how the reflection from a cholesteric liquid crystal material varies with the angle of incidence;

Figure 3 depicts the transmission and reflection of light incident on a liquid crystal material;

15 Figure 4 is a plan view of a security document incorporating a partially embedded security device of the present invention;

20 Figure 5 is a cross sectional side elevation of another embodiment of a security device of the present invention;

25 Figure 6 is a cross sectional side elevation of yet another embodiment of a security device of the present invention;

30 Figures 7a and 7b are plan views of yet another embodiment of the security device of the present invention viewed in reflected light at normal incidence and tilted away from normal incidence respectively;

35 Figure 8 is a plan view of a security document to which two security devices of the present invention have been applied;

40 Figure 9 is a cross sectional side elevation of another embodiment of a security device of the present invention;

45 Figure 10 is a cross sectional side elevation of another embodiment of a security device of the present invention applied to a security document;

50 Figure 11 is a plan view of a security document to which yet another embodiment of a security devices of the present invention has been applied;

55 Figures 12a and 12b are plan views of yet another embodiment of the security device of the present invention viewed in reflected light at normal incidence and tilted away from normal incidence respectively; and

Figures 13 to 15 are cross sectional side elevations of further embodiments of a security device of the present invention.

[0015] Referring to Figures 4 and 5, the present inven-

tion provides a security device 10 for protecting a document of value 11. The security device 10 comprises a first layer of an optically variable liquid crystal material 12 and a second layer of an optically variable liquid crystal material 13, which exhibits different reflective characteristics to the first layer 12. A partial absorbing layer 14 is applied between the first and second liquid crystal layers 12, 13.

[0016] The security device 10 of the present invention can be viewed in reflection or transmission. If the device 10 is intended to be viewed in reflection, then it is preferable to have an additional dark absorbing layer 15 present under the first liquid crystal layer 12.

[0017] In a preferred form of the present invention, at least one of the liquid crystal layers 12, 13, and more preferably both of them, are present as a film. However, the invention is not limited to the use of films and one or all of the liquid crystals layers 12, 13 can be provided by a pigmented liquid crystal coating.

[0018] The security device 10 can be incorporated into secure documents 11 in any of the conventional formats known in the prior art, for example as patches, foils, stripes, strips or threads. The security device 10 can be arranged either wholly on the surface of the document 11, as in the case of a stripe or patch, or can be visible only partly on the surface of the document 10 in the form of a windowed security thread. Security threads are now present in many of the world's currencies as well as vouchers, passports, travellers' cheques and other documents. In many cases the thread is provided in a partially embedded or windowed fashion where the thread appears to weave in and out of the paper and is visible in windows 16 in one or both surfaces of the document 11. One method for producing paper with so-called windowed threads can be found in EP-A-0059056. EP-A-0860298 and WO-A-03095188 describe different approaches for the embedding of wider partially exposed threads into a paper substrate. Wide threads, typically having a width of 2-6mm, are particularly useful as the additional exposed thread surface area allows for better use of optically variable devices, such as that used in the present invention. Figure 4 shows the security device 10 of the present invention incorporated into a security document 11 as a windowed thread with windows 16 of exposed thread and areas 18 of embedded thread.

[0019] In a further embodiment of the invention, the device 10 is incorporated into the document such that regions of the device 10 are viewable from both sides of the document 11. Methods of incorporating a security device such that it is viewable from both sides of the document are described in EP-A-1141480 and WO-A-3054297. In the method described in EP-A-1141480 one side of the device is wholly exposed at one surface of the document in which it is partially embedded, and partially exposed in windows at the other surface of the substrate.

[0020] In the case of a stripe or patch, the security device 10 is prefabricated on a carrier strip 17 and trans-

ferred to the substrate in a subsequent working step. The security device 10 can be applied to the document using an adhesive layer, which is applied either to the security device 10 or the surface of the security document 11 to which the device 10 is to be applied. After transfer, the carrier strip 17 is removed leaving the security device 10 exposed. Alternatively the carrier strip 17 can be left in place to provide an outer protective layer.

[0021] Following the application of the security device 10 the security document 11 generally undergoes further standard security printing processes including one or more of the following; wet or dry lithographic printing, intaglio printing, letterpress printing, flexographic printing, screen-printing, and/or gravure printing. In a preferred embodiment, and to increase the effectiveness of the security device 10 against counterfeiting, the design of the security device 10 can be linked to the document 11 it is protecting by content and registration to the designs and identifying information provided on the document 11.

[0022] Figure 5 shows a cross-sectional view of one embodiment of the present invention suitable for application as a windowed security thread. The security device 10 comprises a carrier strip 17 formed from a suitable polymeric substrate, for example Polyethylene Terephthalate (PET) or Bi-axially Oriented Polypropylene (BOPP), to which is applied an all-over uniform absorbing layer 15. The first optically variable liquid crystal layer 12 is applied over the absorbing layer 15. The liquid crystal layer 12 can be formed on the absorbing layer 15 by coating a polymeric liquid crystal material and curing it to form a film, or by transferring or laminating an already formed liquid crystal film onto the carrier strip 17. A further dark absorbing layer 14 is partially applied on top of the first liquid crystal layer 12, preferably in the form of a design. The second liquid crystal layer 13 is applied over the partial absorbing layer 14 and the exposed regions of the first liquid crystal layer 12. Adhesive layers 19 can be applied to the outer surfaces of the device 10 to improve adherence to the secure document 11.

[0023] The application of a partial absorbing layer 14 between the two liquid crystal layers 12, 13 creates two optically variable regions, Regions A and B. In Region A there is no absorbing layer between the two liquid crystal layers 12, 13 such that the wavelength of reflected light, at any given angle of incidence, is a result of the additive mixing of the individual wavelengths of light reflected from the two liquid crystal layers 12, 13. In Region B there is an absorbing layer 14 between the two liquid crystal layers 12, 13 and the wavelength of reflected light, at any given angle of incidence, is solely the reflected light from the second liquid crystal layer 13.

[0024] In another embodiment of the invention, as illustrated in Figure 6, the first absorbing layer 15 under the first liquid crystal film layer 12 is applied in the form of a design, creating a further optically variable Region C. In Region C there is no absorbing layer under either of the liquid crystal layers 12, 13, and when the device 10

is positioned on a reflective background, the intensity of the transmitted colour reflected back through the liquid crystal layers 12,13 saturates the reflective colour. The transmitted and reflected colours are complementary, for example, a red to green colourshift in reflection is seen as a cyan to magenta colourshift in transmission. When the security device 10 is applied to a predominantly white substrate, then the light transmitted through Region C gives the underlying substrate a noticeable tint of colour which is the complementary colour to the observed reflected colour in Region A.

[0025] Whilst the use of a black, or very dark, substantially totally absorbing layer may give rise to the most strong colourshift effects, other effects may be generated by the use of a partially absorbing layer 14 of other colours or a combination of colours, giving rise to differing apparent colourshift colours. The use of different coloured partially absorbing layers 14 enables the number of optically variable regions to be increased further. The absorbing layers 14,15 of the present invention may comprise a pigmented ink or coating or alternatively a non-pigmented absorbing dye can be used.

[0026] The designs generated by the partial application of one or more of the absorbing layers 14,15 are preferably in the form of images such as patterns, symbols and alphanumeric characters and combinations thereof. The designs can be defined by patterns comprising solid or discontinuous regions which may include for example line patterns, fine filigree line patterns, dot structures and geometric patterns. Possible characters include those from non-Roman scripts of which examples include but are not limited to, Chinese, Japanese, Sanskrit and Arabic.

[0027] In a further embodiment one or both of the liquid crystal layers 12,13 is a partial layer. This can be achieved by gravure printing the liquid crystal material onto the carrier strip 17 or onto the first liquid crystal layer 12 using a printable polymerisable liquid crystal material as described in US-A-20040155221. Where the second liquid crystal layer 13, for example, is a partial layer, such that in certain regions the first liquid crystal layer 12 is exposed, then a further optically variable region can be created in which the wavelength of reflected light, at any given angle of incidence, is solely the reflected light from the first liquid crystal layer 12.

[0028] An alternative method of forming a partial second liquid crystal layer 13 is to remove regions of the exposed second liquid crystal layer 13 once the multilayer device 10 has been formed. This can be achieved by creating a weak interface between the partial absorbing layer 14 and the first liquid crystal layer 12. If a mechanical force is applied such that the second liquid crystal layer 13 is pulled away from the first liquid crystal layer 12 it will be removed along with the absorbing layer 14 only in the regions where this weak interface exists.

[0029] Figures 7a and 7b illustrate one example of the optically variable effect that could be generated from the security device in Figure 5. In this example the first liquid

crystal layer 12 exhibits a red-green colourshift when viewed in reflection over absorbing layer 15 and the second liquid crystal layer 13 exhibits a green-blue colourshift when viewed in reflection (Figure 7a) over the absorbing layer 14. Regions A and B are defined by the partial absorbing layer 14 in-between the two liquid crystal layers 12,13 which, in this example, is applied in the form of alphanumeric characters such that Region B is a repeating pattern of the words DE LA RUE and Region A is the background. When viewed in reflection and at normal incidence to the security device 10, Region A appears yellow as a result of the additive colour mixing of the red reflected light from the first liquid crystal layer 12 and the green reflected light from the second liquid crystal layer 13, and Region B appears green due to the reflected light coming solely from the second liquid crystal layer 13.

[0030] On tilting the device 10 so that it is viewed away from normal incidence (Figure 7b), Region A appears cyan, due to the additive colour mixing from the green reflected light from the first liquid crystal layer 12 and the blue reflected light from the second liquid crystal layer 13, and Region B appears blue due to the reflected light coming solely from the second liquid crystal layer 13. To the authenticator the repeating words DE LA RUE exhibits a green to blue colourshift on tilting away from normal incidence and the background exhibits a yellow to cyan colourshift.

[0031] The security device 10 in Figures 7a and 7b comprises two colourshifting regions which are clearly distinct from each other, even though the two liquid crystal layers 12,13 themselves are not patterned and are uniformly applied over substantially the whole surface of the device 10. The advantage of the present invention is that the customisation is achieved by the straightforward application of a localised absorbing layer on top of the first liquid crystal layer 12. The absorbing layers 14,15 of the present invention, which may comprise a pigmented ink or coating or alternatively a non-pigmented absorbing dark dye, can be straightforwardly applied using any standard printing process for example gravure printing.

[0032] The chiralities of the liquid crystal layers 12,13 may be the same, i.e. both left-handed or right-handed, or different such that one is left-handed and one is right-handed. The chirality does not effect the wavelength reflected but does effect the polarisation state of the reflected wavelength. A liquid crystal layer with a left-handed chirality selectively reflects light of a circular polarisation opposite to that of a liquid crystal layer with a right-handed chirality. By having different chiralities in the two liquid crystal layer 12,13 a further optically variable effect can be obtained when the device 10 is viewed through a circular polariser. This will be explained with reference to the example in Figure 7.

[0033] In this example the first optically variable liquid crystal layer 12 exhibits a red-green colourshift when viewed in reflection over the dark absorbing layer 15 and has a left-handed chirality. The second liquid crystal layer

13 exhibits a green-blue colourshift when viewed in reflection over the dark absorbing layer 14 and has a right-handed chirality. When the device 10 is viewed at normal incidence without a polariser the repeating legend DE LA RUE appears green on a yellow background. When the device 10 is viewed through a circular polariser, which only transmits right-handed circularly polarised light, only the light reflected from the second liquid crystal layer 13 will be transmitted through the polariser and the device 10 will therefore appear a uniform green colour with the repeating words DE LA RUE no longer visible. The same effect can be achieved with two liquid crystal layers 12, 13 of the same chirality by having a $\lambda/2$ phase shift layer between the two liquid crystal layers 12, 13 that reverses the direction of polarisation of the circularly polarised light reflected from the first liquid crystal layer 12.

[0034] Figure 8 shows a security device according to the present invention applied to a security document 11 as a surface element in the form of a stripe 21 and in the form of a patch 22. Figure 9 shows a cross-sectional view of a construction of the security device 10 suitable for application as a surface stripe 21 or patch 22. The device 10 comprises a carrier substrate 17, which may be coated with a release layer 23, onto which is applied a liquid crystal film, which forms the second layer 13 of liquid crystal film. The partial absorbing layer 14 is printed over the liquid crystal layer 13 in the form of a design. A further liquid crystal film, which forms the first liquid crystal layer 12, is then applied over the partial absorbing layer 14 and the exposed regions of the previously applied liquid crystal layer 13. A further partial absorbing layer 15 is printed over the liquid crystal layer 12 in the form of a design. An adhesive layer 19 is applied to cover the partial absorbing layer 15 and exposed areas of the first liquid crystal layer 12. The device 10 is then suitable for transfer to a security document 11, such as a banknote. After transfer the carrier strip 17 can be removed, leaving the second liquid crystal layer 13 exposed, or alternatively the carrier layer 17 can be left in place to form an outer protective layer.

[0035] Figure 10 shows the security device 10 of Figure 9 applied to the surface of a security document 11. The position of the optically variable Regions A, B and C are defined by the location of the two absorber layers 14, 15.

[0036] Figure 11 shows a plan view of the device 10 of Figure 10 with Region A defining the background, Region B defining a repeating pattern of the \$ symbol and Region C defining a repeating pattern of the word STRIPE. For the purpose of this example the liquid crystal layers 12, 13 exhibit the same colourshifts as the example in Figure 4, i.e. the first layer 12 of liquid crystal exhibits a red-green colourshift and the second layer 13 of liquid crystal exhibits a green-blue colourshift. For the same reasons as those described with reference to Figure 6, Region A switches from yellow to cyan on tilting the device 10 away from normal incidence and Region B switches from green to blue on tilting the device away from

normal incidence. In Region C the wavelength of reflected light is the same as that for Region A, but as there is no absorbing layer under either of the liquid crystal layers 12, 13 the intensity of the transmitted colour through the liquid crystal layers 12, 13 saturates the reflective colour. The transmitted and reflected colours are complementary, and therefore a yellow to cyan colourshift in reflection is seen as a blue to red colourshift in transmission. In Region C the light transmitted through the liquid crystal layers 12, 13 is observed against the predominantly white substrate background and gives the substrate a noticeable tint of the transmitted colour.

[0037] In summary, the device 10 shown in Figure 9 comprises three viewing regions (Regions A, B and C) which exhibit contrasting colourshifts. The repeating \$ pattern exhibits a green to blue colourshift, the repeating STRIPE legend exhibits a blue to red colourshift and the background exhibits a yellow to green colourshift.

[0038] In yet a further embodiment of the present invention, liquid crystal materials can be selected such that at certain angles of view the reflected light is in the non-visible wavelengths of the electromagnetic spectrum. The use of polymer liquid crystals where only one component of the colourshift is in the visible region of the electromagnetic spectrum enables an image to be incorporated into the device that only becomes apparent at certain angles of view. In one example, illustrated in Figures 12a and 12b, and referring to the cross-section in Figure 5, the first liquid crystal layer 12 reflects light in the infrared region of the electromagnetic spectrum when at normal incidence (Figure 12a), appearing colourless and transparent, and reflects red light when tilted away from normal incidence (Figure 12b). The second liquid crystal layer 13 exhibits a red-green colourshift when viewed against a dark absorbing background. Regions A and B are defined by the partial dark absorbing layer 14 between the two liquid crystal layers 12, 13 which, in this example, is applied in the form of alphanumeric characters such that Region B is a repeating pattern of the words DE LA RUE and Region A is the background. When viewed in reflection and at normal incidence both Regions A and B will appear red due to the transparent colourless appearance of the first liquid crystal layer 12 having no visible effect on the appearance of the device 10. On tilting the device 10 such that it is viewed away from normal incidence Region A appears yellow, due to the additive colour mixing from the red reflected light from the first liquid crystal layer 12 and the green reflected light from the second liquid crystal layer 13, and Region B appears green due to the reflected light coming solely from the second liquid crystal layer 13. To the authenticator the device 10 appears uniformly red at normal incidence but on tilting away from normal incidence the repeating legend DE LA RUE appears in a yellow colour against a green background.

[0039] In a modification to the example of Figure 12, the first liquid crystal layer 12 comprises a liquid crystal film that reflects blue light when viewed at normal inci-

dence, and reflects ultra-violet light, appearing colourless and transparent, when tilted away from normal incidence. On viewing this embodiment at normal incidence, Region A appears magenta, due to the additive colour mixing from the blue reflected light from the first liquid crystal layer 12 and the red reflected light from the second liquid crystal layer 13, and Region B appears red due to the reflected light coming solely from the second liquid crystal layer 13. On tilting away from normal incidence the first liquid crystal layer 12 reflects ultra-violet light and appears transparent and colourless such that Regions A and B both appear green as a result of the reflected light of the second liquid crystal layer 13. To the authenticator the repeating legend DE LA RUE appears in a red colour against a magenta background at normal incidence, but on tilting away from normal incidence DE LA RUE disappears and the device 10 switches to a uniform green appearance.

[0040] The security device 10 can be used in combination with existing approaches for the manufacture of threads. Examples of suitable methods and constructions that can be used include, but are not limited to, those cited within WO-A-03061980, EP-A-516790, WO-A-9825236, and WO-A-9928852.

[0041] Figure 13 illustrates how the security device 10 can be combined with demetallised indicia 25 using the method described in WO-A-03.061980 for application as a windowed security thread. The method requires a metallised film comprising a substantially clear polymeric film 17 of PET or the like, which has an opaque layer of metal 26 on a first side thereof. A suitable pre-metallised film is metallised MELINEX S film from DuPont of, preferably, 19µm thickness. The metal layer 26 is printed with a resist 27 which contains a black or dark dye or pigment. Suitable resists include the dye BASE Neozapon X51 or the pigment (well dispersed) "Carbon Black 7" mixed into a material with both good adhesion to metal and caustic resistance. The printed metallised film is then partially demetallised, according to a known demetallisation process using a caustic wash which removes the metal in the regions not printed with the resist 27. The remaining metal regions 26, coated with resist 27, provide a partial black layer which is visible when the device 10 is viewed from its first side (along arrow Y) interspersed with clear regions. The black layer is equivalent to the first absorbing layer in Figure 6. The shiny metal of the remaining metal regions 26 are only visible from an opposite side of the device 10 (along arrow X). The resist 27 may be printed in the form of the indicia such as words, numerals, patterns and the like; in which case the resulting indicia will be positively metallised, with the metal still covered by the dark or black resist. Alternatively the resist may be printed so as to form indicia negatively, in which case the resulting indicia will be provided by the demetallised regions. The indicia however formed, are clearly visible from both sides, especially in transmitted light, due to the contrast between the regions of the metal which have been removed and the remaining opaque metal regions

26. The first layer 12 of liquid crystal film, the partial absorbing layer 14 and the second liquid crystal layer 13 are then applied as described with reference to Figure 5. Preferably the absorbing layer 14 is translucent so that it does not conceal the demetallised indicia in transmission, but if it is substantially opaque then the demetallised indicia 25 must be positioned in the gaps in the absorbing layer 14.

[0042] The security device 10 illustrated in Figure 13 exhibits two visually contrasting security characteristics. The device 10 comprises two regions with distinct highly visible colour shift effects, as described in the previous embodiments, when the finished document 11 is viewed in reflection from the first side (along arrow Y); and a metallic shiny partial coating when viewed from the other side (along arrow X). Additionally clear positive or negative indicia, defined by the black resist 27, can be seen in transmission from either side. This embodiment is particularly advantageous when used for a device 10 that is viewable from both side of the document 11 in which it is incorporated. For example the device 10 could be incorporated into a secure document 11 using the methods described in EP-A-1141480 or WO-A03054297.

[0043] Security devices comprising liquid crystal materials are inherently machine-readable due to the polarisation properties and wavelength selectivity of the liquid crystal materials. The machine readable-aspect of the security device 10 of the present invention can be extended further by the introduction of detectable materials in the existing liquid crystal or absorbing layers 12,13,14,15 or by the introduction of separate machine-readable layers. Detectable materials that react to an external stimulus include but are not limited to fluorescent, phosphorescent, infrared absorbing, thermochromic, photochromic, magnetic, electrochromic, conductive and piezochromic materials.

[0044] In one preferred embodiment, the pigment in one of the absorbing layers 14,15 is machine readable, for example carbon black, to produce a machine-readable or conducting layer. Alternatively it may be a magnetic material, such as magnetite, to produce a machine-readable magnetic layer.

[0045] Figure 14 illustrates an approach to forming a machine-readable construction of a security device 10 for application as a windowed security thread. The device 10 comprises a carrier polymeric substrate 17, for example Polyethylene Terephthalate (PET) or Bi-axially Oriented Polypropylene (BOPP), onto which is applied a magnetic material in the form of tramlines 28 along both longitudinal edges of the device 10. A suitable magnetic material is FX 1021 supplied by Ferron and applied with a coat weight of 2-6 gsm. A uniform absorbing layer 15 is applied over both the polymeric substrate 17 and the magnetic tramlines 28. The first layer 12 of liquid crystal material, the partial absorbing layer 14 and the second liquid crystal layer 13 are then applied, as described with reference to Figure 5. An adhesive layer 19 may be applied to the outer surfaces of the device 10 to improve

adherence to the security document 11. The use of magnetic tramlines 28 in this example is for illustrative purposes only, and the magnetic material can be applied in any design.

[0046] In an alternative machine-readable construction one or more of the absorbing layers 14, 15 can be formed using a magnetic pigment, for example magnetite. For example the partial absorbing layer 14 in Figure 5 can be formed from such a magnetic pigment to provide a machine-readable code. In a further embodiment, only part of the partial absorbing layer 14 in Figure 5 is provided with a magnetic pigment and the remainder is provided with a non-magnetic pigment. If both the magnetic and non-magnetic regions are substantially totally absorbing there will be no visual difference in the liquid crystal layer over the two regions and therefore the format of the code will not be readily apparent.

[0047] In an alternative machine-readable embodiment a transparent magnetic layer can be incorporated at any position within the structure of the device 10. Suitable transparent magnetic layers containing a distribution of particles of a magnetic material of a size and distributed in a concentration at which the magnetic layer remains transparent are described in WO-A-03091953 and WO-A-03091952.

[0048] Figure 15 illustrates a machine-readable security device 10 described in Figure 14 combined with the demetallised characters 25 of Figure 13. The device 10 comprises a 12 μm metallised PET base layer 17 demetallised with a suitable design including tramlines 26a of metal are left along each edge of the device 10. As described with reference to Figure 13 a black resist 27 is used during the demetallisation process. A protective layer may be applied onto the metal tramlines 26a to prevent the metal from being corroded by the magnetic layer 28, which is applied next. A suitable protective layer is VHL31534 supplied by Sun Chemical applied with coat weight of 2gsm. The protective layer may optionally be pigmented. The magnetic material 28 is only applied over the metal tramlines 26a so as not to obscure the demetallised indicia 25. The first liquid crystal layer, the partial absorbing layer 14 and the second liquid crystal layer 13 are then applied as described previously. An adhesive layer 19 may be applied to the outer surfaces of the device 10 to improve adherence to the security document 11.

[0049] In all of the embodiments described, where the finished security document 11 has undergone further standard security printing processes, e.g. litho and intaglio, then the colour and/or design of the images/information on the security device 10 can be correlated to the design of the final printed document 11. The patterns and designs on the device 10 and document 11 may be registered with each other, which makes it very difficult to counterfeit.

Claims

1. A security device comprising a first layer (12) of an optically variable liquid crystal material which reflects light of a wavelength depending on the angle of incidence, a second layer of an optically variable liquid crystal material which reflects light at a different wavelength dependent on the angle of incidence to the first layer, and a partial first layer (14) of a light-absorbing material between the first and second liquid crystal layers.
2. A security device as claimed in claim 1 in which the liquid crystal layers are partial layers.
3. A security device as claimed in claim 1 or claim 2 further comprising a second layer of a light-absorbing material on an opposite side of the first liquid crystal layer to the partial first light-absorbing layer.
4. A security device as claimed in claim 3 in which the second light-absorbing layer is a partial layer.
5. A security device as claimed in any one of the preceding claims in which one or both of the partial light-absorbing layers form indicia.
6. A security device as claimed in any one of the preceding claims in which the liquid crystal layers comprise films of liquid crystal material.
7. A security device as claimed in any one of claims 1 to 5 in which the liquid crystal layers comprise coatings of pigmented liquid crystal material.
8. A security device as claimed in any one of the preceding claims in which the light reflected by the liquid crystal layers at certain angles of view is in the non-visible wavelength of the electromagnetic spectrum.
9. A security device as claimed in claim 8 in which the light reflected by the liquid crystal layers at certain angles of view is in the infrared region of the electromagnetic spectrum.
10. A security device as claimed in claim 8 in which the light reflected by the liquid crystal layers at certain angles of view is in the ultra violet region of the electromagnetic spectrum.
11. A security device as claimed in any one of claims 4 to 10 further comprising metallised or demetallised indicia defined by metal regions covered by corresponding regions of the second partial light-absorbing layer.
12. A security device as claimed in any one of the preceding claims further comprising a machine readable

ble element.

13. A security device as claimed in any one of the preceding claims further comprising a supporting carrier substrate.
14. A security device as claimed in claim 13 in which the second liquid crystal layer is applied directly to the carrier substrate.
15. A security device as claimed in claim 13 in which the second light-absorbing layer is applied directly to the carrier substrate.
16. A security device as claimed in claim 13 or claim 14 in which the carrier substrate is removable.
17. A security document comprising a substrate and security device as claimed in any one of the preceding claims.
18. A security document as claimed in claim 17 in which the security device is applied to a surface of the substrate.
19. A security document as claimed in claim 17 or claim 18 comprising a voucher, passport, banknote, cheque, certificate or other document of value.
20. A security document as claimed in claim 17 or claim 18 in which the document is printed with identifying information and designs formed by the reflection of light from the liquid crystal layers of the security device are linked to the identifying information.
21. A method of manufacturing a security device as claimed in any one of claim 1 to 20 comprising the steps of:-applying to a carrier substrate a first layer (12) of optically variable liquid crystal material which reflects light of a wavelength dependent on the angle of incidence; applying a partial layer (14) of light-absorbing material to the first liquid crystal layer; and applying a second layer (13) of optically variable liquid crystal material which reflects light at a different wavelength dependent on the angle of incidence to the first layer to cover the partial light-absorbing layer and the exposed regions of the first liquid crystal layer.
22. A method of manufacturing a security device as claimed in claim 21 further comprising the step of applying a second layer of light-absorbing material to the carrier substrate before the first liquid crystal layer is applied.
23. A method of manufacturing a security device as claimed in claim 21 or 22 in which the liquid crystal layers are applied formed as films.

24. A method of manufacturing a security device as claimed in claim 21 or 22 in which the liquid crystal layer(s) are formed by a coating and curing method.

- 5 25. A method of manufacturing a security device as claimed in any one of claims 21 to 24 in which the light-absorbing layer(s) are applied by a coating method.
- 10 26. A method of manufacturing a security device as claimed in any one of claims 21 to 24 further comprising the step of forming metallised or demetallised indicia on the carrier substrate.
- 15 27. A method of manufacturing a security device as claimed in claim 26 in which the metallised or demetallised indicia are formed by applying the partial second light-absorbing layer in the form of a dark resist to regions of a metallised carrier substrate leaving exposed metal therebetween and removing the exposed metal.
- 20

Patentansprüche

- 25 1. Sicherheitsvorrichtung, umfassend eine erste Schicht (12) aus optisch veränderlichem Flüssigkristallmaterial, das Licht einer Wellenlänge in Abhängigkeit vom Einfallswinkel reflektiert, eine zweite Schicht (13) aus optisch veränderlichem Flüssigkristallmaterial, das Licht mit einer verschiedenen Wellenlänge in Abhängigkeit vom Einfallswinkel auf die erste Schicht reflektiert, und eine partielle erste Schicht (14) aus lichtabsorbierendem Material zwischen der ersten und der zweiten Flüssigkristallschicht.
- 30 2. Sicherheitsvorrichtung nach Anspruch 1, worin die Flüssigkristallschichten partielle Schichten sind.
- 35 3. Sicherheitsvorrichtung nach Anspruch 1 oder Anspruch 2, die ferner eine zweite Schicht aus lichtabsorbierendem Material auf einer zur partiellen ersten lichtabsorbierenden Schicht entgegengesetzten Seite der ersten Flüssigkristallschicht aufweist.
- 40 4. Sicherheitsvorrichtung nach Anspruch 3, worin die zweite lichtabsorbierende Schicht eine partielle Schicht ist.
- 45 5. Sicherheitsvorrichtung nach einem der vorhergehenden Ansprüche, worin eine oder beide der partiellen lichtabsorbierenden Schichten Zeichen bilden.
- 50 6. Sicherheitsvorrichtung nach einem der vorhergehenden Ansprüche, worin die Flüssigkristallschichten Filme aus Flüssigkristallmaterial aufweisen.
- 55

7. Sicherheitsvorrichtung nach einem der Ansprüche 1 bis 5, worin die Flüssigkristallschichten Beschichtungen aus pigmentiertem Flüssigkristallmaterial aufweisen. 5
8. Sicherheitsvorrichtung nach einem der vorhergehenden Ansprüche, worin das Licht, das bei bestimmten Blickwinkeln von den Flüssigkristallschichten reflektiert wird, in der nicht-sichtbaren Wellenlänge des elektromagnetischen Spektrums liegt. 10
9. Sicherheitsvorrichtung nach Anspruch 8, worin das Licht, das bei bestimmten Blickwinkeln von den Flüssigkristallschichten reflektiert wird, im Infrarotbereich des elektromagnetischen Spektrums liegt. 15
10. Sicherheitsvorrichtung nach Anspruch 8, worin das Licht, das bei bestimmten Blickwinkeln von den Flüssigkristallschichten reflektiert wird, im Ultraviolettbereich des elektromagnetischen Spektrums liegt. 20
11. Sicherheitsvorrichtung nach einem der Ansprüche 4 bis 10, das ferner metallisierte oder entmetallisierte Zeichen aufweist, die durch Metallbereiche definiert sind, die durch entsprechende Bereiche der zweiten partiellen lichtabsorbierenden Schicht bedeckt sind. 25
12. Sicherheitsvorrichtung nach einem der vorhergehenden Ansprüche, die ferner ein maschinenlesbares Element aufweist. 30
13. Sicherheitsvorrichtung nach einem der vorhergehenden Ansprüche, die ferner ein stützendes Trägersubstrat aufweist. 35
14. Sicherheitsvorrichtung nach Anspruch 13, worin die zweite Flüssigkristallschicht direkt auf das Trägersubstrat aufgebracht ist.
15. Sicherheitsvorrichtung nach Anspruch 13, worin die zweite lichtabsorbierende Schicht direkt auf das Trägersubstrat aufgebracht ist. 40
16. Sicherheitsvorrichtung nach Anspruch 13 oder Anspruch 14, worin das Trägersubstrat entfernbar ist. 45
17. Sicherheitsdokument, das ein Substrat und eine Sicherheitsvorrichtung nach einem der vorhergehenden Ansprüche aufweist. 50
18. Sicherheitsdokument nach Anspruch 17, worin die Sicherheitsvorrichtung auf eine Oberfläche des Substrats aufgebracht ist.
19. Sicherheitsdokument nach Anspruch 17 oder Anspruch 18, das einen Gutschein, einen Pass, eine Banknote, einen Scheck, ein Zertifikat oder ein anderes Wertdokument aufweist. 55
20. Sicherheitsdokument nach Anspruch 17 oder Anspruch 18, worin das Dokument mit Identifikationsinformation bedruckt ist, und Designs, die durch die Lichtreflektion von den Flüssigkristallschichten der Sicherheitsvorrichtung gebildet werden, mit der Identifikationsinformation gekoppelt sind.
21. Verfahren zum Herstellen einer Sicherheitsvorrichtung nach einem der Ansprüche 1 bis 20, welches die Schritte umfasst:
 Aufbringen einer ersten Schicht (12) aus optisch veränderlichem Flüssigkristallmaterial, das Licht einer Wellenlänge in Abhängigkeit vom Einfallswinkel reflektiert, auf ein Trägersubstrat;
 Aufbringen einer partiellen Schicht (14) aus lichtabsorbierendem Material auf die erste Flüssigkristallschicht; und
 Aufbringen einer zweiten Schicht (13) aus optisch veränderlichem Flüssigkristallmaterial, das Licht mit einer verschiedenen Wellenlänge in Abhängigkeit vom Einfallswinkel auf die erste Schicht reflektiert, um die partielle lichtabsorbierende Schicht und die freiliegenden Bereiche der ersten Flüssigkristallschicht zu bedecken.
22. Verfahren zum Herstellen einer Sicherheitsvorrichtung nach Anspruch 21, das ferner den Schritt umfasst, eine zweite Schicht aus lichtabsorbierendem Material auf das Trägersubstrat aufzubringen, bevor die erste Flüssigkristallschicht aufgebracht wird.
23. Verfahren zum Herstellen einer Sicherheitsvorrichtung nach Anspruch 21 oder 22, worin die Flüssigkristallschichten in Form von Filmen aufgebracht werden.
24. Verfahren zum Herstellen einer Sicherheitsvorrichtung nach Anspruch 21 oder 22, worin die Flüssigkristallschicht(en) durch ein Beschichtungs- und Härtingsverfahren aufgebracht werden.
25. Verfahren zum Herstellen einer Sicherheitsvorrichtung nach einem der Ansprüche 21 bis 24, worin die lichtabsorbierende Schicht(en) durch ein Beschichtungsverfahren aufgebracht werden.
26. Verfahren zum Herstellen einer Sicherheitsvorrichtung nach einem der Ansprüche 21 bis 24, das ferner den Schritt umfasst, metallisierte oder entmetallisierte Zeichen auf dem Trägersubstrat auszubilden.
27. Verfahren zum Herstellen einer Sicherheitsvorrichtung nach Anspruch 26, worin die metallisierten oder entmetallisierten Zeichen gebildet werden, indem die partielle zweite lichtabsorbierende Schicht in der Form von Dunkelresist auf Bereiche eines metallisierten Trägersubstrats aufgebracht wird, wobei frei-

liegendes Material dazwischen belassen wird, und das freiliegende Material entfernt wird.

Revendications

1. Dispositif de sécurité comprenant une première couche (12) d'un matériau à cristaux liquides optiquement variable qui réfléchit la lumière d'une longueur d'onde en fonction de l'angle d'incidence, une deuxième couche (13) d'un matériau à cristaux liquides optiquement variable qui réfléchit la lumière à une longueur d'onde différente en fonction de l'angle d'incidence à la première couche, et une première couche partielle (14) d'un matériau absorbant la lumière entre les première et deuxième couches de cristaux liquides. 10
2. Dispositif de sécurité selon la revendication 1, dans lequel les couches de cristaux liquides sont des couches partielles. 20
3. Dispositif de sécurité selon la revendication 1 ou 2, comprenant en outre une deuxième couche d'un matériau absorbant la lumière sur un côté opposé de la première couche de cristaux liquides à la première couche partielle absorbant la lumière. 25
4. Dispositif de sécurité selon la revendication 3, dans lequel la deuxième couche absorbant la lumière est une couche partielle. 30
5. Dispositif de sécurité selon l'une quelconque des revendications précédentes, dans lequel l'une ou les deux couches partielles absorbant la lumière forment des indices. 35
6. Dispositif de sécurité selon l'une quelconque des revendications précédentes, dans lequel les couches de cristaux liquides comprennent des films de matériau à cristaux liquides. 40
7. Dispositif de sécurité selon l'une quelconque des revendications 1 à 5, dans lequel les couches de cristaux liquides comprennent des revêtements de matériau à cristaux liquides pigmenté. 45
8. Dispositif de sécurité selon l'une quelconque des revendications précédentes, dans lequel la lumière réfléchie par les couches de cristaux liquides à certains angles de vue est dans la longueur d'onde non visible du spectre électromagnétique. 50
9. Dispositif de sécurité selon la revendication 8, dans lequel la lumière réfléchie par les couches de cristaux liquides à certains angles de vue est dans le domaine infrarouge du spectre électromagnétique. 55
10. Dispositif de sécurité selon la revendication 8, dans lequel la lumière réfléchie par les couches de cristaux liquides à certains angles de vue est dans le domaine de l'ultraviolet du spectre électromagnétique.
11. Dispositif de sécurité selon l'une quelconque des revendications 4 à 10, comprenant en outre des indices métallisés ou démétallisés définis par des régions métalliques couvertes par des régions correspondantes de la deuxième couche partielle absorbant la lumière.
12. Dispositif de sécurité selon l'une quelconque des revendications précédentes, comprenant en outre un élément lisible par machine.
13. Dispositif de sécurité selon l'une quelconque des revendications précédentes, comprenant en outre un substrat de support.
14. Dispositif de sécurité selon la revendication 13, dans lequel la deuxième couche de cristaux liquides est appliquée directement au substrat de support.
15. Dispositif de sécurité selon la revendication 13, dans lequel la deuxième couche absorbant la lumière est appliquée directement au substrat de support.
16. Dispositif de sécurité selon la revendication 13 ou 14, dans lequel le substrat de support est amovible.
17. Document de sécurité comprenant un substrat et un dispositif de sécurité selon l'une quelconque des revendications précédentes.
18. Document de sécurité selon la revendication 17, dans lequel le dispositif de sécurité est appliqué à une surface du substrat.
19. Document de sécurité selon la revendication 17 ou 18, comprenant un bon, un passeport, un billet de banque, un chèque, un certificat ou autre document de valeur.
20. Document de sécurité selon la revendication 17 ou 18, dans lequel le document est imprimé avec des informations d'identification et des conceptions formées par réflexion de la lumière à partir des couches de cristaux liquides du dispositif de sécurité sont liées aux informations d'identification.
21. Procédé de fabrication d'un dispositif de sécurité selon l'une quelconque des revendications 1 à 20, comprenant les étapes consistant :

à appliquer à un substrat de support une première couche (12) de matériau à cristaux liquides.

- des optiquement variable qui réfléchit la lumière d'une longueur d'onde en fonction de l'angle d'incidence ;
à appliquer une couche partielle (14) de matériau absorbant la lumière à la première couche de cristaux liquides ; et à appliquer une deuxième couche (13) de matériau à cristaux liquides optiquement variable qui réfléchit la lumière à une longueur d'onde différente en fonction de l'angle d'incidence à la première couche pour couvrir la couche partielle absorbant la lumière et les régions exposées de la première couche de cristaux liquides. 5 10
- 22.** Procédé de fabrication d'un dispositif de sécurité selon la revendication 21, comprenant en outre l'étape consistant à appliquer une deuxième couche de matériau absorbant la lumière au substrat de support avant l'application de la première couche de cristaux liquides. 15 20
- 23.** Procédé de fabrication d'un dispositif de sécurité selon la revendication 21 ou 22, dans lequel les couches de cristaux liquides sont appliquées sous forme de films. 25
- 24.** Procédé de fabrication d'un dispositif de sécurité selon la revendication 21 ou 22, dans lequel la/les couche(s) de cristaux liquides est/sont formée(s) par un revêtement et un procédé de durcissement. 30
- 25.** Procédé de fabrication d'un dispositif de sécurité selon l'une quelconque des revendications 21 à 24, dans lequel la/les couche(s) absorbant la lumière est/sont appliquée(s) par un procédé de revêtement. 35
- 26.** Procédé de fabrication d'un dispositif de sécurité selon l'une quelconque des revendications 21 à 24, comprenant en outre l'étape consistant à former des indices métallisés ou démétallisés sur le substrat de support. 40
- 27.** Procédé de fabrication d'un dispositif de sécurité selon la revendication 26, dans lequel les indices métallisés ou démétallisés sont formés en appliquant la deuxième couche partielle absorbant la lumière sous forme d'une réserve sombre à des régions d'un substrat de support métallisé laissant entre elles un métal exposé et éliminant le métal exposé. 45 50

55

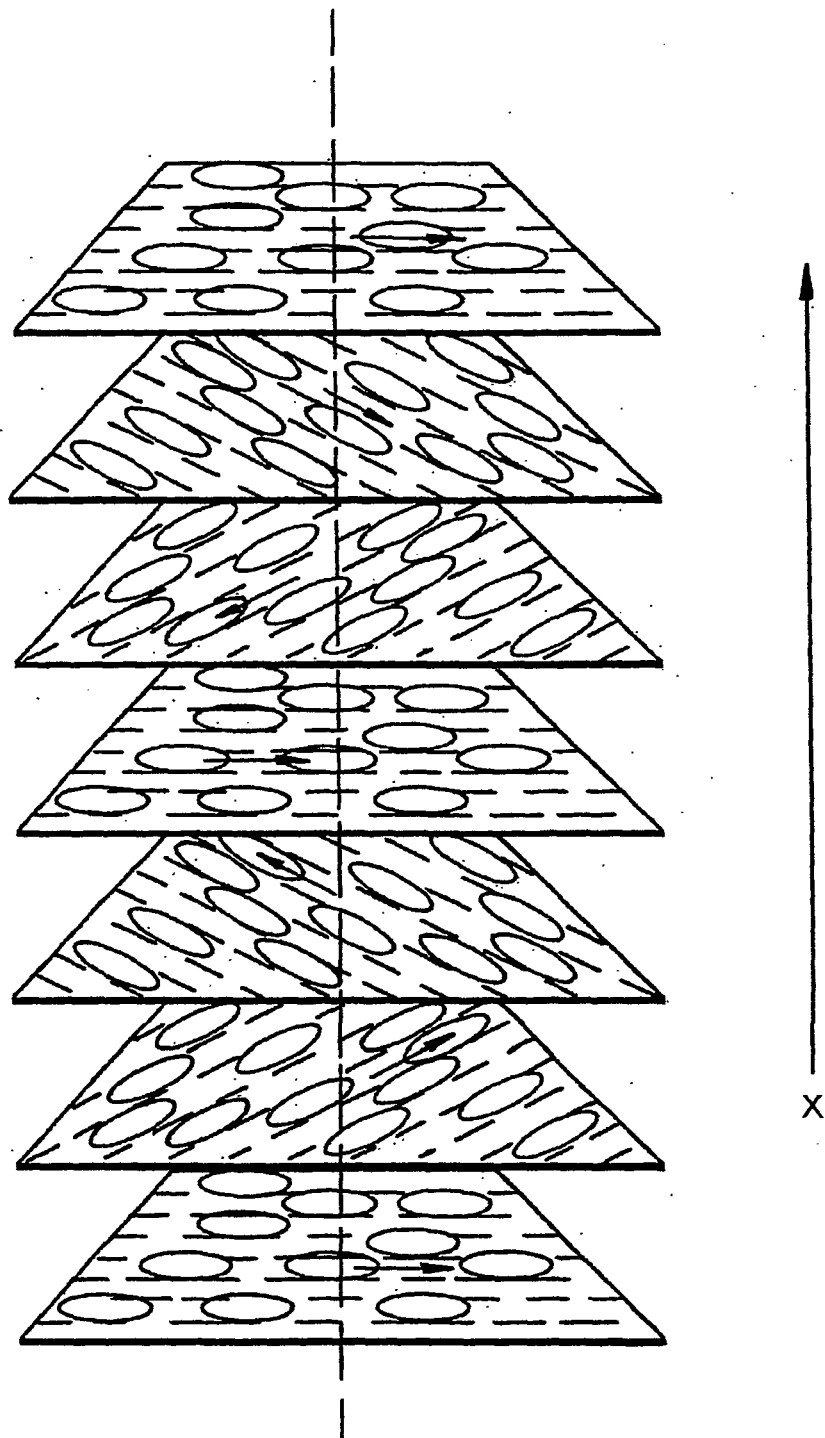


FIG. 1

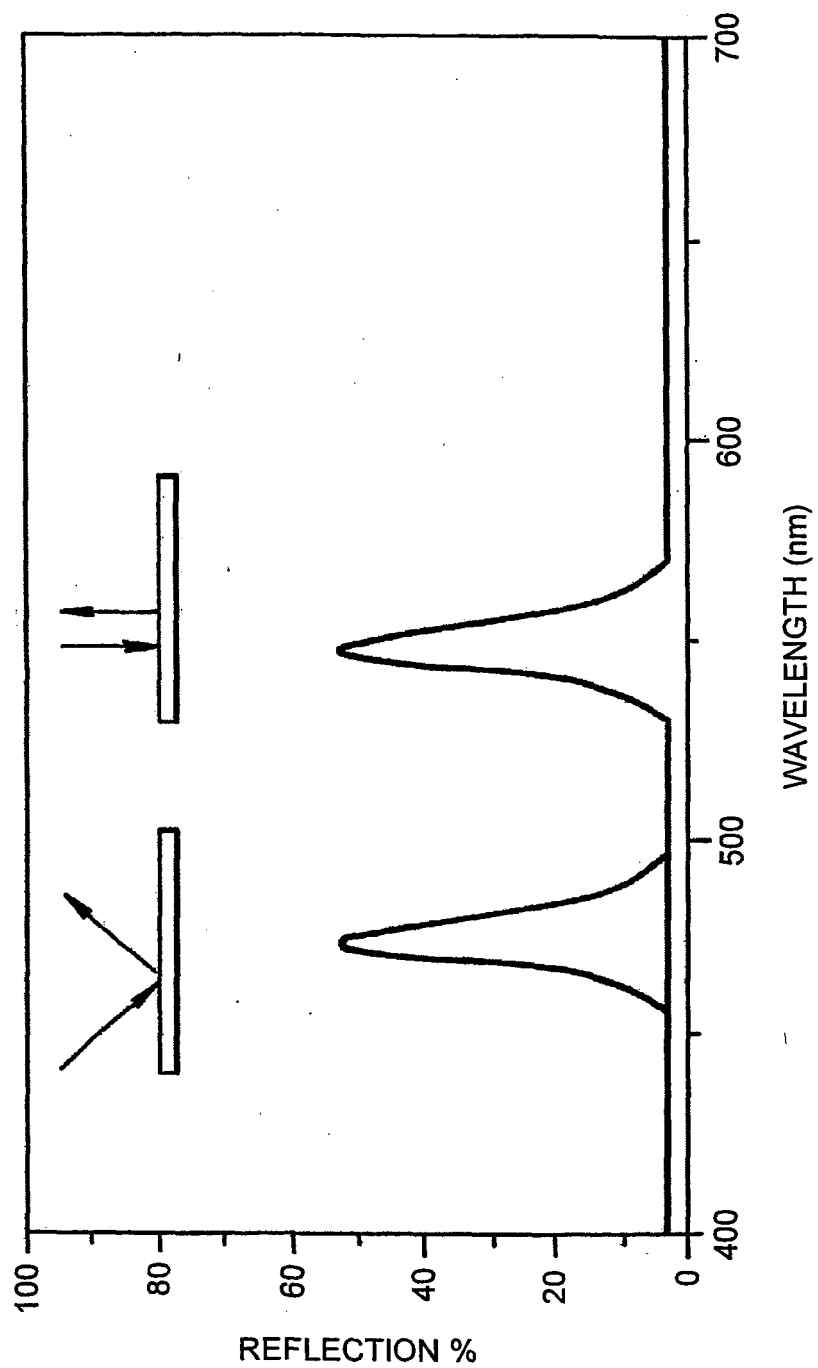


FIG. 2

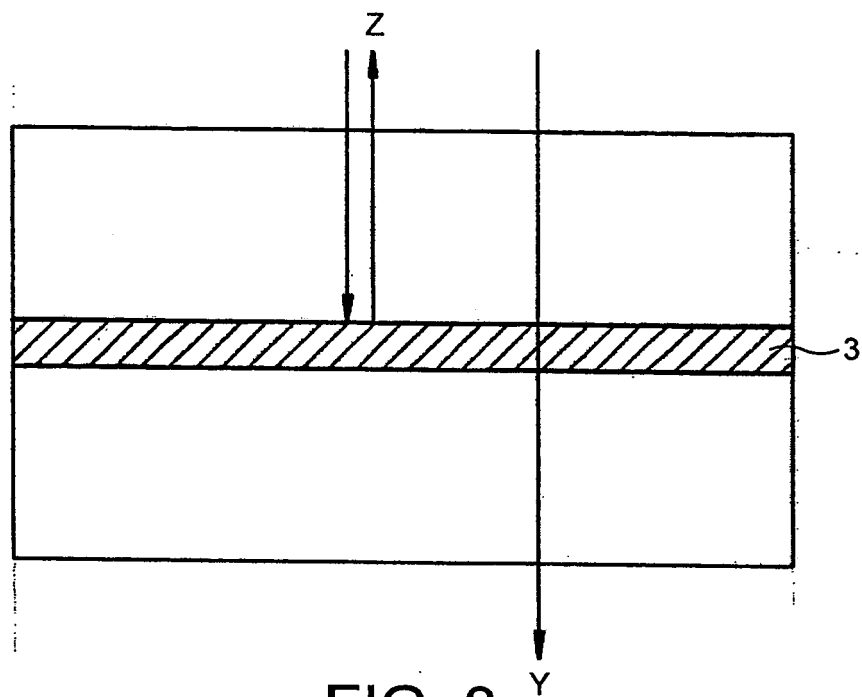


FIG. 3

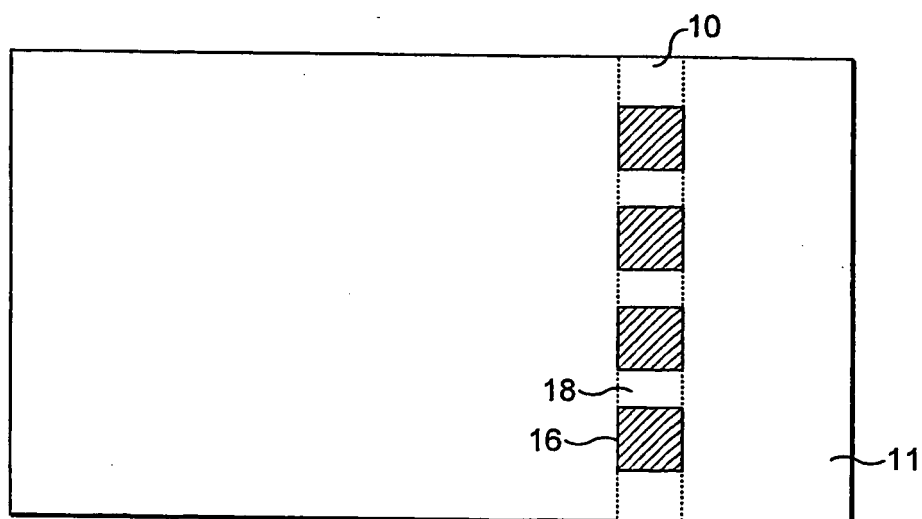


FIG. 4

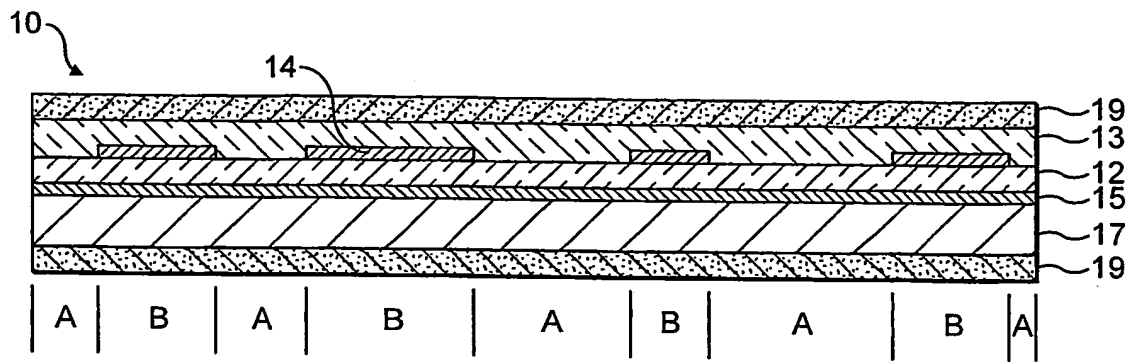


FIG. 5

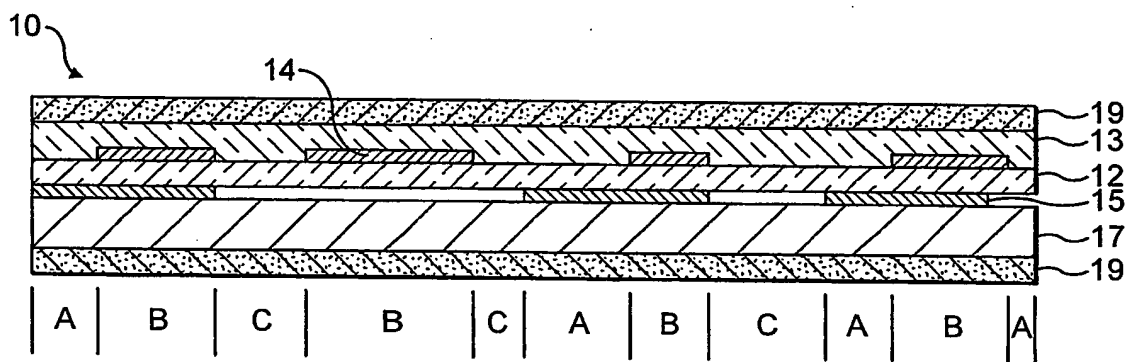


FIG. 6

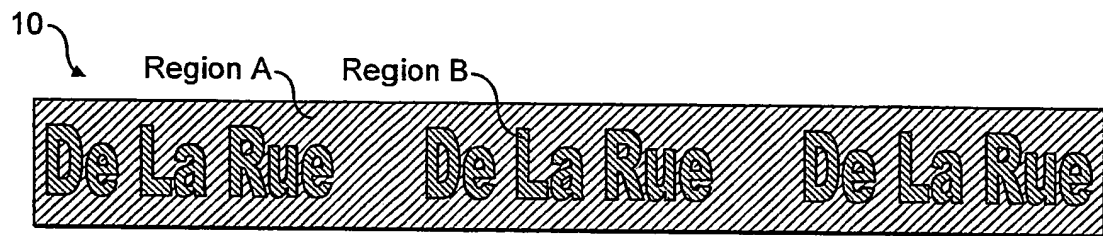


FIG. 7a

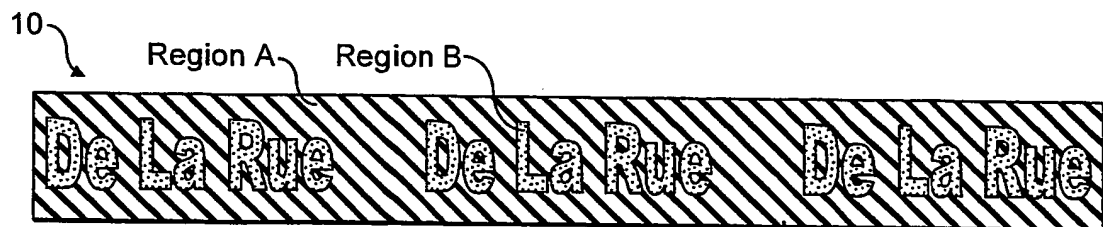


FIG. 7b

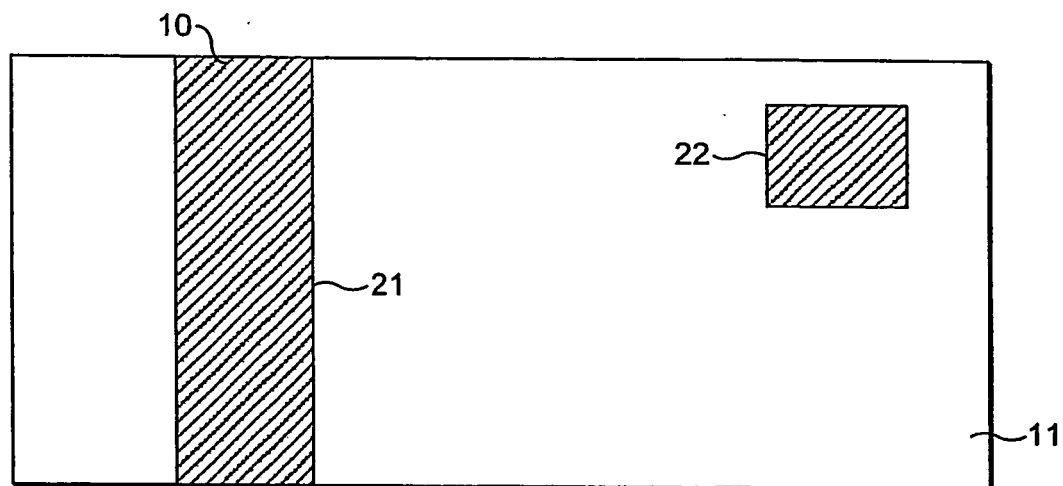


FIG. 8

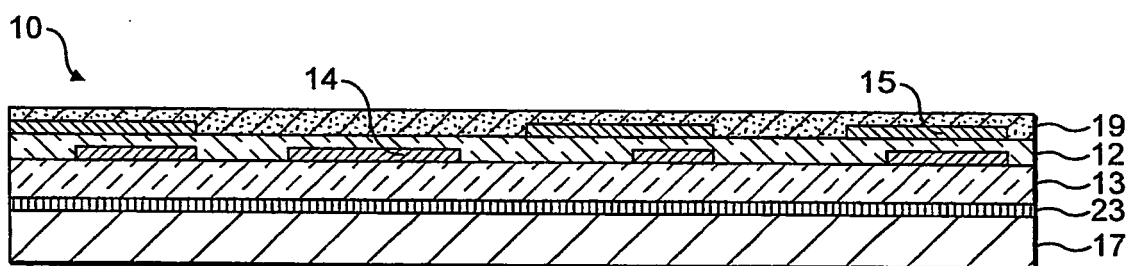


FIG. 9

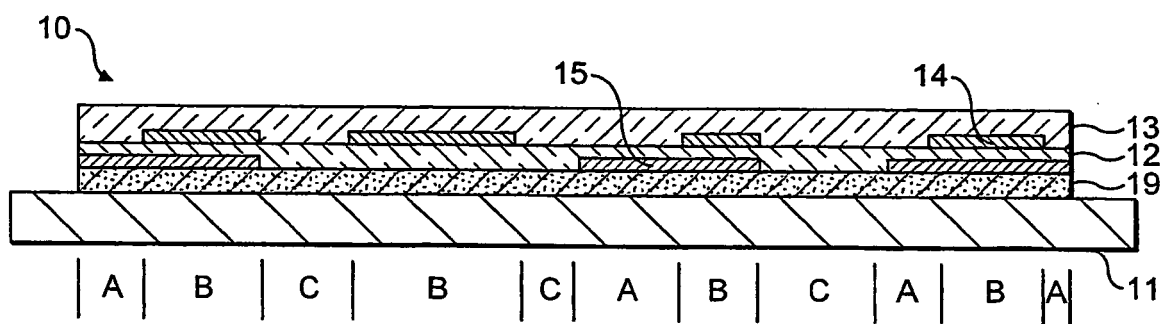


FIG. 10

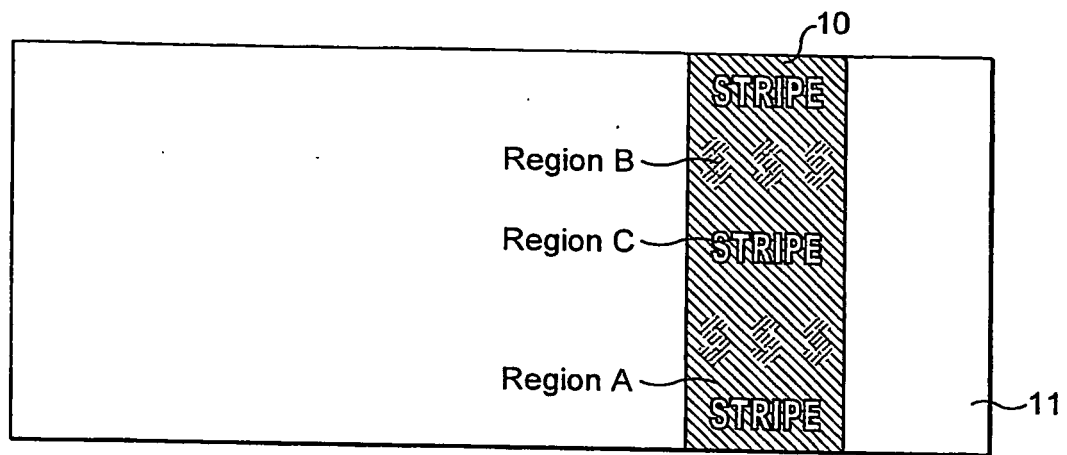


FIG. 11

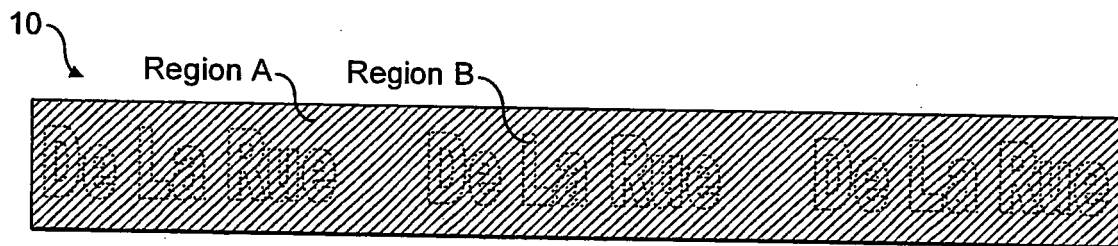


FIG. 12a

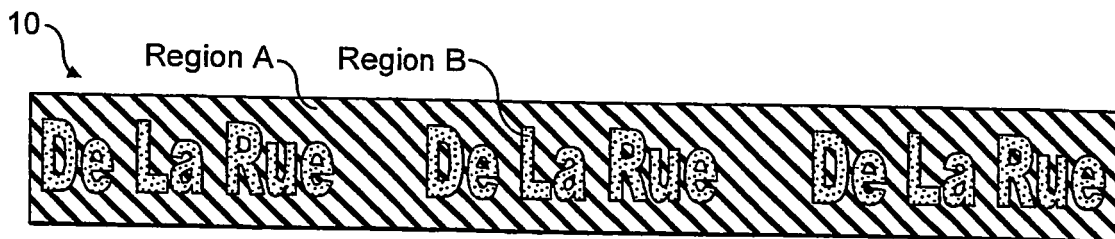


FIG. 12b

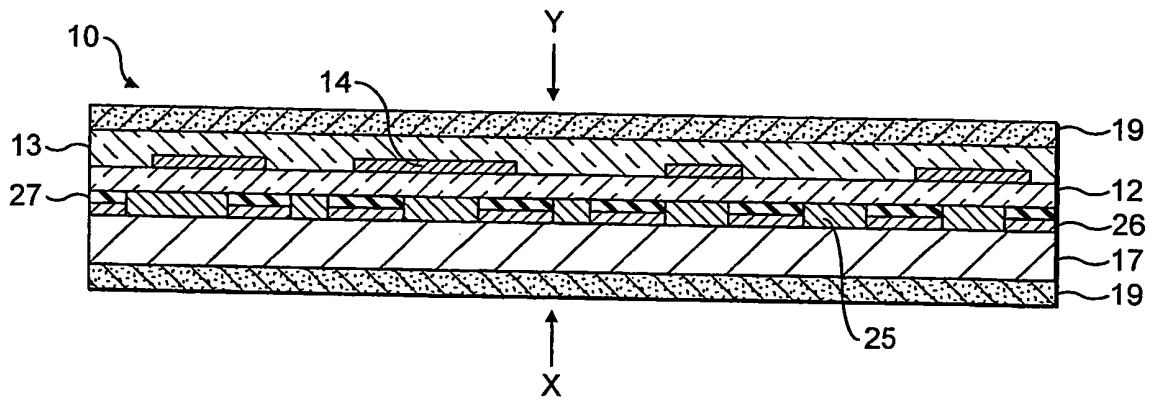


FIG. 13

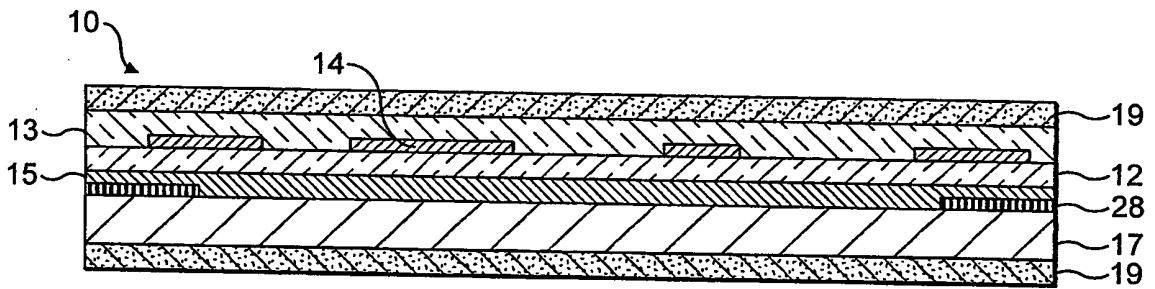


FIG. 14

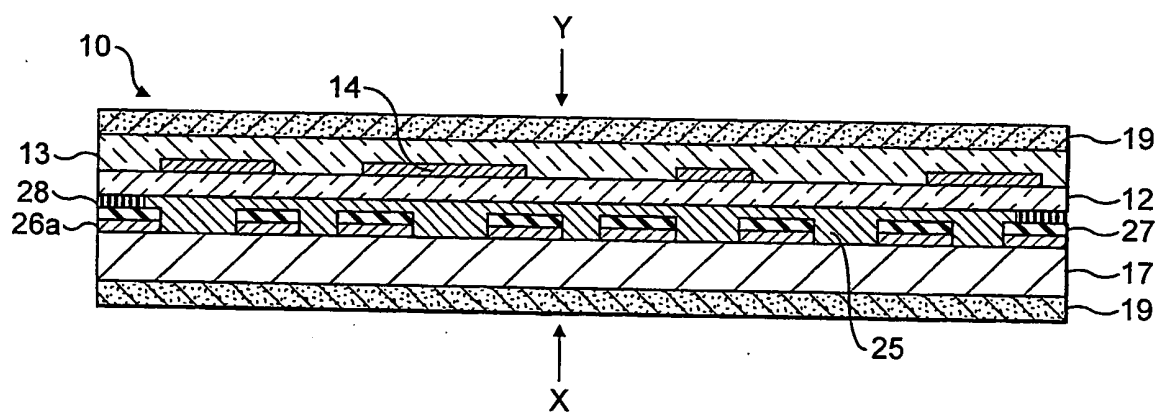


FIG. 15

REFERENCES CITED IN THE DESCRIPTION

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